

GROUNDWATER BACKGROUND DOCUMENT

Parts of the data evaluation performed in the Data Summary Report (Volume 2, Appendix B of the Feasibility Study) and the Baseline Risk Assessment (Volume 3, Appendix C of the Feasibility Study) relied on screening constituent concentrations against those which may be naturally occurring (i.e., background).

Constituent concentrations in groundwater were screened against background concentrations presented in the following draft document.

The reader is cautioned that the values derived in the following draft background document are provisional and subject to significant revision.

Draft

**Feasibility Study
for the Groundwater Operable Unit
at Paducah Gaseous Diffusion Plant
Paducah, Kentucky**

**Volume 5. Appendix D
Groundwater Background Document**

Date Issued—August 2001

**Prepared for the
Department of Energy
Office of Environmental Management**

**By
Bechtel Jacobs Company LLC
managing the**

**Environmental Management Activities at the
Paducah Gaseous Diffusion Plant
Paducah, Kentucky 42001
managed by
Bechtel Jacobs Company LLC
for the
U.S. Department of Energy
under contract DE-AC05-98OR22700**

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

contributed to the preparation of this document and should not
be considered an eligible contractor for its review.

KY/EM-XXX

**BACKGROUND CONCENTRATIONS
OF NATURALLY OCCURRING INORGANIC
CHEMICALS
AND
SELECTED RADIONUCLIDES
IN THE
REGIONAL GRAVEL AQUIFER
AND
MCNAIRY FORMATION
AT THE
PADUCAH GASEOUS DIFFUSION PLANT,
PADUCAH, KENTUCKY**

AUGUST 2001

THIS PAGE INTENTIONALLY LEFT BLANK

**BACKGROUND CONCENTRATIONS OF
NATURALLY OCCURRING INORGANIC CHEMICALS
AND
SELECTED RADIONUCLIDES
IN THE
REGIONAL GRAVEL AQUIFER
AND
MCNAIRY FORMATION
AT THE
PADUCAH GASEOUS DIFFUSION PLANT,
PADUCAH, KENTUCKY**

Date Issued—August 2001

Prepared by
Center for Information Studies
The University of Tennessee
Knoxville, TN
and
Scientific Applications International Corporation
Oak Ridge, TN

Prepared for the
U.S. Department of Energy
Office of Environmental Restoration and Waste Management
under budget and reporting code EW 20

Environmental Management Activities at the
PADUCAH GASEOUS DIFFUSION PLANT
Paducah, Kentucky 42002
managed by
BECHTEL JACOBS COMPANY LLC
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR22700

PREFACE

This report presents background concentrations for naturally occurring inorganic chemicals and selected radionuclides found in groundwater drawn from the Regional Gravel Aquifer (RGA) and the McNairy Formation at the Paducah Gaseous Diffusion Plant (PGDP), Paducah, Kentucky. In addition, this report compares the background concentrations to human health risk-based concentrations to develop a list of screening criteria that can be used to identify significant contamination in these groundwater sources at this facility. Such screening criteria are required for Resource Conservation and Recovery Act Appendix IX and Contract Laboratory Program total analyte list inorganic chemicals and for radionuclides to ensure that remedial investigations and feasibility studies for identified areas of concern and solid waste management units at PGDP focus on those contaminants that may influence human health risk. In addition, appropriate screening criteria are needed to determine if areas currently not under investigation should be added to the list of those areas to be investigated at PGDP. These values are to be used when completing work plans and reports produced as part of the environmental restoration and waste management programs at PGDP. The work was performed under Work Breakdown Structure 1.4.12.7.1.02.04 entitled Corrective Measures for Offsite Contamination.

THIS PAGE INTENTIONALLY LEFT BLANK

CONTENTS

PREFACE	v
FIGURES	xi
TABLES	xiii
ACRONYMS	xv
EXECUTIVE SUMMARY	xvii
1. INTRODUCTION	1-1
1.1 REGULATORY ISSUES	1-1
1.2 ORGANIZATION OF THE REPORT	1-1
2. DATA EVALUATION	2-1
2.1 SELECTION OF BACKGROUND WELLS	2-1
2.1.1 Evaluation of Background Wells for the RGA	2-3
2.1.2 Evaluation of Background Wells for the McNairy Formation	2-5
2.2 DATA EVALUATION	2-9
2.2.1 Reasons for Removing or Correcting Inorganic Chemical Data	2-10
2.2.2 Reasons for Removing or Correcting Radionuclide Data	2-10
2.2.3 Summary of Data Evaluation	2-11
3. DERIVATION AND PRESENTATION OF BACKGROUND VALUES	2-16
3.1 GROUP 1 ANALYTES AND DERIVATION OF THEIR BACKGROUND VALUES	3-17
3.2 GROUP 2 ANALYTES AND DERIVATION OF THEIR BACKGROUND VALUES	3-20
3.3 DERIVATION OF BACKGROUND CONCENTRATIONS FOR URANIUM ISOTOPES	3-25
3.4 SUMMARY OF BACKGROUND CONCENTRATIONS	3-26
4. SOURCES OF RISK-BASED CONCENTRATIONS AND OTHER COMPARISON CRITERIA	4-1
4.1 RISK-BASED CONCENTRATIONS	4-1
4.2 REGULATORY VALUES	4-1
4.3 LITERATURE VALUES	4-3
5. RESULTS AND DISCUSSION	5-1
5.1 COMPARISON OF BACKGROUND CONCENTRATIONS TO RBCs, MCLs, and KDEP RISK-BASED SCREENING VALUES	5-1
5.1.1 Aluminum	5-1
5.1.2 Aluminum, Dissolved	5-1
5.1.3 Antimony	5-1
5.1.4 Antimony, Dissolved	5-10
5.1.5 Arsenic	5-10
5.1.6 Arsenic, Dissolved	5-10
5.1.7 Barium	5-10
5.1.8 Barium, Dissolved	5-11
5.1.9 Beryllium	5-11

5.1.10	Beryllium, Dissolved	5-11
5.1.11	Cadmium	5-11
5.1.12	Cadmium, Dissolved	5-12
5.1.13	Calcium.....	5-12
5.1.14	Calcium, Dissolved.....	5-12
5.1.15	Chloride	5-12
5.1.16	Chromium.....	5-12
5.1.17	Chromium, Dissolved	5-13
5.1.18	Cobalt.....	5-13
5.1.19	Cobalt, Dissolved.....	5-13
5.1.20	Copper	5-13
5.1.21	Copper, Dissolved	5-13
5.1.22	Fluoride.....	5-14
5.1.23	Iron.....	5-14
5.1.24	Iron, Dissolved.....	5-14
5.1.25	Lead	5-14
5.1.26	Lead, Dissolved	5-15
5.1.27	Magnesium	5-15
5.1.28	Magnesium, Dissolved	5-15
5.1.29	Manganese	5-15
5.1.30	Manganese, Dissolved	5-15
5.1.31	Mercury	5-16
5.1.32	Mercury, Dissolved	5-16
5.1.33	Molybdenum.....	5-16
5.1.34	Molybdenum, Dissolved.....	5-16
5.1.35	Nickel.....	5-17
5.1.36	Nickel, Dissolved.....	5-17
5.1.37	Nitrate as Nitrogen.....	5-17
5.1.38	Potassium.....	5-17
5.1.39	Potassium, Dissolved.....	5-18
5.1.40	Selenium	5-18
5.1.41	Selenium, Dissolved.....	5-18
5.1.42	Silica	5-18
5.1.43	Silver.....	5-18
5.1.44	Silver, Dissolved.....	5-19
5.1.45	Sodium.....	5-19
5.1.46	Sodium, Dissolved.....	5-19
5.1.47	Sulfate	5-19
5.1.48	Thallium.....	5-20
5.1.49	Thallium, Dissolved.....	5-20
5.1.50	Uranium.....	5-20
5.1.51	Uranium, Dissolved	5-20
5.1.52	Vanadium.....	5-20
5.1.53	Vanadium, Dissolved.....	5-21
5.1.54	Zinc.....	5-21
5.1.55	Zinc, Dissolved.....	5-21
5.1.56	Gross Alpha	5-21
5.1.57	Gross Beta.....	5-22
5.1.58	Neptunium-237	5-22
5.1.59	Plutonium-239	5-22
5.1.60	Radium-226	5-22

5.1.61	Radon-222	5-22
5.1.62	Technetium-99	5-23
5.1.63	Thorium-230	5-23
5.1.64	Total Radium	5-23
5.1.65	Uranium-234	5-23
5.1.66	Uranium-235	5-24
5.1.67	Uranium-238	5-24
5.1.68	Summary of Comparisons Between Background Concentrations and RBCs, MCLs, and KDEP Screening Values	5-24
5.2	COMPARISON OF BACKGROUND CONCENTRATIONS TO VALUES CONTAINED IN EARLIER REPORTS AND FOUND IN THE OPEN LITERATURE	5-40
5.2.1	Aluminum	5-49
5.2.2	Aluminum, Dissolved	5-49
5.2.3	Antimony	5-49
5.2.4	Antimony, Dissolved	5-50
5.2.5	Arsenic	5-50
5.2.6	Arsenic, Dissolved	5-50
5.2.7	Barium	5-50
5.2.8	Barium, Dissolved	5-51
5.2.9	Beryllium	5-51
5.2.10	Beryllium, Dissolved	5-51
5.2.11	Cadmium	5-52
5.2.12	Cadmium, Dissolved	5-52
5.2.13	Calcium	5-52
5.2.14	Calcium, Dissolved	5-52
5.2.15	Chloride	5-53
5.2.16	Chromium	5-53
5.2.17	Chromium, Dissolved	5-53
5.2.18	Cobalt	5-53
5.2.19	Cobalt, Dissolved	5-54
5.2.20	Copper	5-54
5.2.21	Copper, Dissolved	5-54
5.2.22	Fluoride	5-54
5.2.23	Iron	5-55
5.2.24	Iron, Dissolved	5-55
5.2.25	Lead	5-55
5.2.26	Lead, Dissolved	5-55
5.2.27	Magnesium	5-56
5.2.28	Magnesium, Dissolved	5-56
5.2.29	Manganese	5-56
5.2.30	Manganese, Dissolved	5-57
5.2.31	Mercury	5-57
5.2.32	Mercury, Dissolved	5-57
5.2.33	Molybdenum	5-57
5.2.34	Molybdenum, Dissolved	5-58
5.2.35	Nickel	5-58
5.2.36	Nickel, Dissolved	5-58
5.2.37	Nitrate as Nitrogen	5-58
5.2.38	Potassium	5-59
5.2.39	Potassium, Dissolved	5-59

5.2.40	Selenium	5-59
5.2.41	Selenium, Dissolved	5-59
5.2.42	Silica	5-60
5.2.43	Silver	5-60
5.2.44	Silver, Dissolved	5-60
5.2.45	Sodium	5-60
5.2.46	Sodium, Dissolved	5-61
5.2.47	Sulfate	5-61
5.2.48	Thallium	5-61
5.2.49	Thallium, Dissolved	5-61
5.2.50	Uranium	5-62
5.2.51	Uranium, Dissolved	5-62
5.2.52	Vanadium	5-62
5.2.53	Vanadium, Dissolved	5-62
5.2.54	Zinc	5-63
5.2.55	Zinc, Dissolved	5-63
5.2.56	Gross Alpha	5-63
5.2.57	Gross Beta	5-63
5.2.58	Neptunium-237	5-64
5.2.59	Plutonium-239	5-64
5.2.60	Radium-226	5-64
5.2.61	Radon-222	5-64
5.2.62	Technetium-99	5-64
5.2.63	Thorium-230	5-65
5.2.64	Total Radium	5-65
5.2.65	Uranium-234	5-65
5.2.66	Uranium-235	5-65
5.2.67	Uranium-238	5-65
5.2.68	Summary of Comparisons Between Background Concentrations and Values Found in Earlier Reports and the Open Literature	5-66
5.3	UNCERTAINTIES AFFECTING BACKGROUND CONCENTRATIONS	5-68
5.3.1	Data Set Uncertainties	5-68
5.3.2	Method of Calculation	5-70
6.	BIBLIOGRAPHY	6-75
	APPENDIX A – WELL SUMMARY INFORMATION	A-1
	APPENDIX B – DATA SUMMARIES FOR SELECTED BACKGROUND WELLS	B-1
	APPENDIX C – RESULTS OF REGRESSION AND CORRELATION ANALYSES FOR TURBIDITY AND DISSOLVED SOLIDS	C-1

FIGURES

2.1	Background well locations	2-2
5.1	Summary of comparisons of background concentrations to risk-based criteria.....	5-25

Draft

THIS PAGE INTENTIONALLY LEFT BLANK

TABLES

ES-1	Background concentrations in total and filtered samples taken from the Regional Gravel Aquifer and McNairy Formation derived over all observations, residential use risk-based concentrations, and maximum contaminant levels.....	xix
ES-2	Background concentrations in total and filtered samples taken from the Regional Gravel Aquifer and McNairy Formation derived over averages within wells, residential use risk-based concentrations, and maximum contaminant levels.....	xxi
2.1	Initial well list.....	2-1
2.2	Summary of evaluation of RGA inorganic chemical data.....	2-12
2.3	Summary of evaluation of McNairy Formation inorganic chemical data	2-13
2.4	Summary of evaluation of RGA and McNairy Formation radionuclide data	2-15
3.1	Group 1 analytes and their background values–RGA data sets.....	3-18
3.2	Group 1 analytes and their background values–McNairy Formation data sets	3-19
3.3	Background values for Group 2 analytes over all observations–RGA data sets	3-21
3.4	Background values for Group 2 analytes over wells–RGA data sets.....	3-22
3.5	Background values for Group 2 analytes over all observations–McNairy Formation data sets.....	3-23
3.6	Background values for Group 2 analytes over wells–McNairy Formation data sets	3-24
3.7	Parameters used to convert total uranium concentrations to isotopic uranium concentrations	3-26
3.8	Summary of selected RGA and McNairy Formation background concentrations	3-27
4.1	RBCs, MCLs, and Commonwealth of Kentucky risk-based screening values	4-2
4.2	Reference values for groundwater taken from earlier reports produced for the PGDP and from literature sources.....	4-4
5.1	Comparison of RGA background concentrations derived over all observations against RBCs, MCLs, and Commonwealth of Kentucky risk-based screening values	5-2
5.2	Comparison of RGA background concentrations derived over averages within wells against RBCs, MCLs, and Commonwealth of Kentucky risk-based screening values	5-4
5.3	Comparison of McNairy Formation background concentrations derived over all observations against RBCs, MCLs, and Commonwealth of Kentucky risk-based screening values	5-6
5.4	Comparison of McNairy Formation background concentrations derived over averages within wells against RBCs, MCLs, and Commonwealth of Kentucky risk-based screening values.....	5-8
5.5	Factors of difference for the comparison of RGA background concentrations derived over all observations against RBCs, MCLs, and Commonwealth of Kentucky risk-based screening values	5-27
5.6	Factors of difference for the comparison of RGA background concentrations derived over averages within wells against RBCs, MCLs, and Commonwealth of Kentucky risk-based screening values	5-30
5.7	Factors of difference for the comparison of McNairy Formation background concentrations derived over all observations against RBCs, MCLs, and Commonwealth of Kentucky risk-based screening values	5-32
5.8	Factors of difference for the comparison of McNairy Formation background concentrations derived over averages within wells against RBCs, MCLs, and Commonwealth of Kentucky risk-based screening values	5-34
5.9	Comparison between RGA background concentrations over all observations derived in this report and background concentrations derived in the Tech Report, Site Investigation, and Moore Report or drawn from the open literature	5-41
5.10	Comparison between RGA background concentrations over averages within wells derived in this report and background concentrations derived in the Tech Report, Site Investigation, and Moore Report or drawn from the open literature.....	5-43

5.11	Comparison between McNairy Formation background concentrations over all observations derived in this report and background concentrations drawn from the open literature	5-45
5.12	Comparison between McNairy Formation background concentrations over averages within wells derived in this report and background concentrations drawn from the open literature.....	5-47
5.13	Comparison of mean inorganic chemical concentrations derived over all observations from RGA background data against RBCs, MCLs, Commonwealth of Kentucky risk-based screening values, and open literature values.....	5-73
5.14	Comparison of mean inorganic chemical concentrations derived over all observations from McNairy Formation background data against RBCs, MCLs, Commonwealth of Kentucky risk-based screening values, and open literature values	5-74

Draft

ACRONYMS

bgs	below ground surface
DOE	United States Department of Energy
ELCR	excess lifetime cancer risk
EPA	United States Environmental Protection Agency
HI	hazard index
IDs	identifiers
KDEP	Kentucky Department of Environmental Protection
PGDP	Paducah Gaseous Diffusion Plant
PQL	practical quantitation limit
RBCs	risk based concentrations
RGA	Regional Gravel Aquifer
TCE	trichloroethene

Draft

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

This report documents the methods used to develop background concentrations of naturally occurring inorganic chemicals and selected radionuclides present in groundwater drawn from the Regional Gravel Aquifer (RGA) and the McNairy Formation at the Paducah Gaseous Diffusion Plant (PGDP) located near Paducah, Kentucky. This report also presents the background concentrations developed and compares these concentrations to human health risk-based concentrations. Subsequent to this comparison, a list of screening criteria for the naturally occurring chemicals and selected radionuclides is developed. This list is provided so that users can determine if detected concentrations of naturally occurring inorganic chemicals and selected radionuclides are present at levels that represent contamination and at levels that may present an unacceptable risk to the health of groundwater users.

All data used in the development of the background concentrations were from groundwater taken from wells not believed to be impacted by contaminant releases from PGDP. The identifiers, general location, and screen depth of the background RGA wells are:

- MW103, south of the PGDP, deep RGA—79.5 to 90 feet below ground surface (ft bgs);
- MW106, northwest of the PGDP, middle RGA—62 to 75 ft bgs;
- MW141, west northwest of the PGDP, deep RGA—79 to 80 ft bgs;
- MW142, west northwest of the PGDP, upper RGA—42.5 to 52.5 ft bgs;
- MW150, east of the PGDP, deep RGA—66 to 96 ft bgs; and
- MW199, northwest of the PGDP, upper RGA—57 to 62 ft bgs.

The identifiers, general location, and screen depth of the background McNairy Formation wells are:

- MW102, south of the PGDP, middle McNairy Formation—136 to 146 ft bgs;
- MW120, southeast of the PGDP, deep McNairy Formation—160 to 170 ft bgs;
- MW121, northwest of the PGDP, deep McNairy Formation—200 to 210 ft bgs;
- MW122, east of the PGDP, middle McNairy Formation—148 to 158 ft bgs;
- MW133, northeast of the PGDP, upper McNairy Formation—80 to 90 ft bgs;
- MW140, west northwest of the PGDP, middle McNairy Formation—138 to 148 ft bgs;

Two additional McNairy Formation wells were considered for selection as background wells. These were MW239 and MW247. These wells, which are located in the north and south well fields installed as part of the northwest plume interim remedial action, were subsequently not selected as background wells because sampling results indicated that groundwater at these locations and depths may contain a primary PGDP contaminant, trichloroethene (TCE).

In the analyses of the groundwater data from these wells, data were summarized both over all observations within group (i.e., RGA and McNairy Formation) and over wells within group. Analyses were completed in this manner to ensure that the effect of temporal correlation between samples from a single well and the impact of varying well data set sizes could be examined. It should be noted that no attempt was made to adjust the background calculations for the effect of spatial correlation. This adjustment was not attempted because a preliminary analysis indicated that the number of wells within each group was not sufficient to allow for the estimation of any spatial correlation effects. If spatial correlation does exist, then the background concentrations may be underestimated. This effect is due to underestimation of the standard deviations and errors used in the derivation of the background concentrations (see Gilbert 1987; page 35). In any case, the net effect of not considering spatial correlation is that the background concentrations are unlikely to exceed the true background concentrations.

For inorganic chemicals, background concentrations were derived for both total and filtered samples over all observations within group and over wells within group after evaluating and correcting the data sets. Important reasons for correcting the data sets are listed below.

- Value in the data set was a nondetect, but the value was greater than the greatest detected concentration. In this case, the nondetect value was reduced to the greatest detected concentration in other samples taken from the well.
- Value was a detect that was much greater (generally more than 10×'s greater) than the next greatest detected concentration and appeared to be related to sample turbidity. In this case, the value was reduced to the next greatest detected concentration.
- Data point was for a filtered sample and was qualified "Q". In the data set used to derive the background concentrations, data points were "Q" qualified when analyses on a filtered sample were not performed because the results of the analyses of the total (unfiltered) sample were below the total sample's practical quantitation limit. In this case, the "Q" qualified data were modified by assigning to the data point the minimum detection limit of all samples taken from the well, or if there were no other nondetect results for the well, the minimum detection limit across all wells. This was done to ensure that the information such "nondetects" carry was included in the derivation of the background values.

For radionuclides, background concentrations were derived for total samples only because there were too few results from filtered samples. As with the summarization of the data for inorganic chemicals, some data were corrected during this activity. Reasons for correction of data for radionuclides were similar to those for inorganic chemicals.

Background concentrations for naturally occurring inorganic chemicals and selected radionuclides when data are summarized over all observations within group and summarized over wells within group are presented in Tables ES-1 and ES-2, respectively. In each of these tables, the background concentrations for inorganic chemicals in total and filtered samples and for radionuclides in total samples are listed by groundwater source. Also, human health risk-based concentrations (RBCs) based on residential use of groundwater and maximum contaminant limits (MCLs) are presented in each table.

Table ES-1. Background concentrations in total and filtered samples taken from the Regional Gravel Aquifer and McNairy Formation derived over all observations, residential use risk-based concentrations, and maximum contaminant levels

Analyte	Regional Gravel Aquifer		McNairy Formation		Risk-based Concentration ^a	Maximum Contaminant Level ^q
	Total Samples	Filtered Samples	Total Samples	Filtered Samples		
Inorganic Chemicals (mg/L)						
Aluminum	2.189	0.311	0.687	0.579	1.5 ^{HI}	0.050 - 0.200 ^k
Antimony	0.060 ^b	0.060 ^b	0.060 ^b	0.060 ^b	0.00056 ^{HI}	0.006
Arsenic	0.005 ^b	0.005 ^b	0.005 ^b	0.005 ^b	0.000035 ^{CR}	0.050
Barium	0.235	0.200	0.296	0.268	0.10 ^{HI}	2.000
Beryllium	0.004 ^b	0.004 ^b	0.017 ^b	0.004 ^b	0.000010 ^{CR}	0.004
Cadmium	0.010 ^b	0.010 ^b	0.010 ^b	0.010 ^b	0.00066 ^{HI}	0.005
Calcium	41.238	38.166	38.858	38.829	No Value	No Value
Chloride	91.021	No Data	19.708	No Data	No Value	250.000 ^k
Chromium ^d	0.144	0.050 ^b	0.060 ^b	0.050 ^b	0.0071 ^{HI}	0.100
Cobalt	0.045 ^b	0.045 ^b	0.096	0.045 ^b	0.091 ^{HI}	No Value
Copper	0.036	0.020	0.057	0.013 ^b	0.060 ^{HI}	1.300
Fluoride	0.270	No Data	0.330	No Data	0.091 ^{HI}	4.000
Iron	5.030	0.267	18.360	12.372	0.45 ^{HI}	0.300 ^k
Lead	0.129 ^c	0.098 ^c	0.050 ^b	0.050 ^b	0.00000015 ^{HI}	0.015
Magnesium	16.262	16.215	13.418	14.171	No Value	No Value
Manganese	0.119	0.068	0.941	0.894	0.067 ^{HI}	0.050 ^k
Mercury	0.0002 ^b	0.0002 ^c	0.0002	0.0002 ^c	0.00044 ^{HI}	0.002
Molybdenum	0.050 ^b	0.050 ^b	0.050 ^b	0.050 ^b	0.0075 ^{HI}	No Value
Nickel	0.682	0.305	0.109 ^b	0.050 ^b	0.030 ^{HI}	0.100 ^o
Nitrate as Nitrogen	15.561	No Data	1.474	No Data	2.40 ^{HI}	10.000
Potassium	5.195	4.096	55.752	51.205	No Value	No Value
Selenium	0.005 ^b	0.005 ^c	0.005 ^b	0.005 ^c	0.0075 ^{HI}	0.050
Silica	26.401	No Data	26.0	No Data	No Value	No Value
Silver	0.011 ^b	0.060 ^b	0.050 ^b	0.050 ^b	0.0075 ^{HI}	0.100 ^k
Sodium	59.450	60.433	29.2	27.98	No Value	No Value
Sulfate	19.947	No Data	28.9	No Data	No Value	500.000 ^h
Thallium	0.056 ^b	0.056 ^b	0.644	0.056 ^b	No Value	0.002
Uranium	0.002 ^b	0.002 ^c	0.001	0.001 ^c	0.0045 ^{HI}	0.020 ^h
Vanadium	0.134	0.134	0.126	0.126	0.0092 ^{HI}	No Value
Zinc	0.054	0.049	0.142	0.116	0.45 ^{HI}	5.000 ^k
Radionuclides (pCi/L)						
Gross Alpha	5.8	No Data	11.9	No Data	No Value	15 ^h
Gross Beta	13.8	No Data	144.5	No Data	No Value	i
Neptunium-237 ^l	0.8	No Data	0.5	No Data	0.13 ^{CR}	i
Plutonium-239	0.1	No Data	0.2	No Data	0.12 ^{CR}	i
Radium-226 ^m	0.6	No Data	1.2	No Data	0.13 ^{CR}	5 ^p
Radon-222 ⁿ	626	No Data	295	No Data	1.4 ^{CR}	300 ^h
Technetium-99	22.3	No Data	20.6	No Data	28.0 ^{CR}	i
Thorium-230	1.1	No Data	1.5	No Data	1.0 ^{CR}	i
Total Radium ^f	1.3	No Data	0.7	No Data	0.13 ^{CR}	5 ^p
Uranium-234 ^g	0.7	0.33	0.3	No Data	0.87 ^{CR}	j
Uranium-235 ^g	0.3	0.015	0.2	No Data	0.82 ^{CR}	j
Uranium-238 ^g	0.7	0.35	0.3	No Data	0.62 ^{CR}	j

Notes:

No Data indicates that a background concentration could not be derived because data were inadequate or not available.
 No Value under "Risk-based Concentration" indicates that a value could not be derived because the analyte lacks toxicity values. No Value under "Maximum Contaminant Level" indicates that neither a primary nor a secondary maximum contaminant level was available.

Table ES-1. (continued)

- ^a All risk-based concentrations (RBCs) were derived using methods presented in Appendix 2 of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1506&D1, as modified by comments from regulatory agencies). In each case, the value reported is the lesser of the RBCs based on child systemic toxicity (HI) and lifetime cancer risk (CR). For HI, all values are based on a target of 0.1. For CR, all values are based on a target of 1×10^{-6} .
- ^b This analyte was not detected in any sample used in the background calculations or infrequently detected at concentrations similar to their detection limit. Therefore, the reported "background concentration" is the minimum detection limit used for the analyte. If lower detection limits are used in future sampling and analytical efforts, then the background concentration for this analyte should be reevaluated.
- ^c The calculated 95% Upper Tolerance Limit (95% UTL) for this analyte exceeded the analyte's maximum detected value. Therefore, the background concentration selected for the analyte was the analyte's maximum detected value.
- ^d Background values are for total chromium. Risk-based concentration is for Chromium VI.
- ^e All data for this analyte were "Q" qualified. The definition of this qualifier is, "No result available or not required because total analyses is less than PQL." Therefore, the reported "background concentration" is the minimum detection limit used for the total analyses. If lower detection limits are used in future sampling and analytical efforts, then the background concentration for this analyte should be reevaluated.
- ^f The risk-based concentration for Total Radium is that for radium-226 (+D). That value is the smallest of all those for radium isotopes.
- ^g Background values for uranium isotopes were calculated from the uranium metal background concentration because data for individual isotopes was lacking. In this calculation, the natural abundance, by weight, (i.e., 0.0056% U-234, 0.72% U-235, and 99.27% U-238) and the specific activities (i.e., 6.21×10^6 pCi/mg U-234, 2.15×10^3 pCi/mg U-235, and 3.35 pCi/mg U-238) of the uranium isotopes were used. The RBCs for Uranium-235 and Uranium-238 were calculated using the cancer slope factors for Uranium-235+D and Uranium-238+D, respectively.
- ^h Proposed value.
- ⁱ If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or any organ is not to exceed 4 mrem/year.
- ^j Proposed MCL for natural uranium (0.020 mg/L) is approximately equal to 30 pCi/L. This value applies to the sum of all isotopes.
- ^k Secondary MCL.
- ^l Risk-based concentration calculated using cancer slope factors for Neptunium+D.
- ^m Risk-based concentration calculated using cancer slope factors for Radium-226+D.
- ⁿ Risk-based concentration calculated using cancer slope factors for Radon-222+D.
- ^o The EPA has deleted from the CFR both the MCL and the MCLG for nickel which have been vacated by court ruling, effective February 23, 1995 (60 FR 33926, June 29, 1995).
- ^p The MCLs listed here for Radium-226 and Total Radium actually apply to combined Radium-226 and Radium-228.
- ^q Federal and state MCLs were taken from the "Federal and State Guidelines" page found at the "Risk Assessment Information System" site at http://risk.lsd.ornl.gov/cgi-bin/guide/GUID_9709.

Table ES-2. Background concentrations in total and filtered samples taken from the Regional Gravel Aquifer and McNairy Formation derived over averages within wells, residential use risk-based concentrations, and maximum contaminant levels

Analyte	Regional Gravel Aquifer		McNairy Formation		Risk-based Concentration ^a	Maximum Contaminant Level ^q
	Total Samples	Filtered Samples	Total Samples	Filtered Samples		
Inorganic Chemicals (mg/L)						
Aluminum	1.64	0.201	0.75	0.587	1.5 ^{HI}	0.050 - 0.200 ^k
Antimony	0.060 ^b	0.060 ^b	0.060 ^b	0.060 ^b	0.00056 ^{HI}	0.006
Arsenic	0.005 ^b	0.005 ^b	0.005 ^b	0.005 ^b	0.000035 ^{CR}	0.050
Barium	0.202	0.179	0.265	0.266	0.10 ^{HI}	2.000
Beryllium	0.004 ^b	0.004 ^b	0.017 ^b	0.004 ^b	0.000010 ^{CR}	0.004
Cadmium	0.010 ^b	0.010 ^b	0.010 ^b	0.010 ^b	0.00066 ^{HI}	0.005
Calcium	40.0	35.8	39.47	40.27	No Value	No Value
Chloride	89.2	No Data	20.23	No Data	No Value	250.000 ^k
Chromium ^d	0.134	0.050 ^b	0.060 ^b	0.050 ^b	0.0071 ^{HI}	0.100
Cobalt	0.045 ^b	0.045 ^b	0.072	0.045 ^b	0.091 ^{HI}	No Value
Copper	0.034	0.018	0.033	0.013 ^b	0.060 ^{HI}	1.300
Fluoride	0.245	No Data	0.298	No Data	0.091 ^{HI}	4.000
Iron	3.72	0.164	15.83	9.446	0.45 ^{HI}	0.300 ^k
Lead	0.250	0.250	0.050 ^b	0.050 ^b	0.00000015 ^{HI}	0.015
Magnesium	15.7	15.4	16.457	16.533	No Value	No Value
Manganese	0.082	0.048	0.729	0.682	0.067 ^{HI}	0.050 ^k
Mercury	0.0002 ^b	0.0002 ^e	0.0002 ^b	0.0002 ^e	0.00044 ^{HI}	0.002
Molybdenum	0.050 ^b	0.050 ^b	0.050 ^b	0.050 ^b	0.0075 ^{HI}	No Value
Nickel	0.682	0.305	0.109 ^b	0.050 ^b	0.030 ^{HI}	0.100 ^o
Nitrate as Nitrogen	13.5	No Data	1.43	No Data	2.40 ^{HI}	10.000
Potassium	4.47	3.70	64.080	58.750	No Value	No Value
Selenium	0.005 ^b	0.005 ^e	0.005 ^b	0.005 ^e	0.0075 ^{HI}	0.050
Silica	21.1	No Data	29.4	No Data	No Value	No Value
Silver	0.011 ^b	0.060 ^b	0.050 ^b	0.050 ^b	0.0075 ^{HI}	0.100 ^k
Sodium	63.5	65.7	24.92	25.90	No Value	No Value
Sulfate	19.1	No Data	27.27	No Data	No Value	500.000 ^h
Thallium	0.056 ^b	0.056 ^b	0.255	0.056 ^b	No Value	0.002
Uranium	0.002 ^b	0.002 ^e	0.001 ^b	0.001	0.0045 ^{HI}	0.020 ^h
Vanadium	0.139	0.131	0.119	0.107	0.0092 ^{HI}	No Value
Zinc	0.025	0.026	0.104	0.080	0.45 ^{HI}	5.000 ^k
Radionuclides (pCi/L)						
Gross Alpha	2.36	No Data	5.3	No Data	No Value	15 ^h
Gross Beta	7.3	No Data	125.4	No Data	No Value	i
Neptunium-237 ^l	0.21	No Data	0.13	No Data	0.13 ^{CR}	i
Plutonium-239	0.03	No Data	0.04	No Data	0.12 ^{CR}	i
Radium-226 ^m	0.10	No Data	0.29	No Data	0.13 ^{CR}	5 ^p
Radon-222 ⁿ	555.3	No Data	228.3	No Data	1.4 ^{CR}	300 ^h
Technetium-99	10.8	No Data	7.8	No Data	28.0 ^{CR}	i
Thorium-230	0.54	No Data	0.40	No Data	1.0 ^{CR}	i
Total Radium ^f	0.46	No Data	0.36	No Data	0.13 ^{CR}	5 ^p
Uranium-234 ^g	0.7	0.33	0.3	No Data	0.87 ^{CR}	j
Uranium-235 ^g	0.3	0.015	0.2	No Data	0.82 ^{CR}	j
Uranium-238 ^g	0.7	0.35	0.3	No Data	0.62 ^{CR}	j

Notes:

No Data indicates that a background concentration could not be derived because data were inadequate or not available.

No Value under "Risk-based Concentration" indicates that a value could not be derived because the analyte lacks toxicity values. No Value under "Maximum Contaminant Level" indicates that neither a primary nor a secondary maximum contaminant level was available.

Table ES-2. (continued)

- a All risk-based concentrations (RBCs) were derived using methods presented in Appendix 2 of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1506&D1, as modified by comments from regulatory agencies). In each case, the value reported is the lesser of the RBCs based on child systemic toxicity (HI) and lifetime cancer risk (CR). For HI, all values are based on a target of 0.1. For CR, all values are based on a target of 1×10^{-6} .
- b This analyte was not detected in any sample used in the background calculations or infrequently detected at concentrations similar to their detection limit. Therefore, the reported "background concentration" is the minimum detection limit used for the analyte. If lower detection limits are used in future sampling and analytical efforts, then the background concentration for this analyte should be reevaluated.
- c The calculated 95% Upper Tolerance Limit (95% UTL) for this analyte exceeded the analyte's maximum detected value. Therefore, the background concentration selected for the analyte was the analyte's maximum detected value.
- d Background values are for total chromium. Risk-based concentration is for Chromium VI.
- e All data for this analyte were "Q" qualified. The definition of this qualifier is, "No result available or not required because total analyses is less than PQL." Therefore, the reported "background concentration" is the minimum detection limit used for the total analyses. If lower detection limits are used in future sampling and analytical efforts, then the background concentration for this analyte should be reevaluated.
- f The risk-based concentration for Total Radium is that for radium-226 (+D). That value is the smallest of all those for radium isotopes.
- g Background values for uranium isotopes were calculated from the uranium metal background concentration because data for individual isotopes was lacking. In this calculation, the natural abundance, by weight, (i.e., 0.0056% U-234, 0.72% U-235, and 99.27% U-238) and the specific activities (i.e., 6.21×10^6 pCi/mg U-234, 2.15×10^3 pCi/mg U-235, and 3.35 pCi/mg U-238) of the uranium isotopes were used. The RBCs for Uranium-235 and Uranium-238 were calculated using the cancer slope factors for Uranium-235+D and Uranium-238+D, respectively.
- h Proposed value.
- i If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or any organ is not to exceed 4 mrem/year.
- j Proposed MCL for natural uranium (0.020 mg/L) is approximately equal to 30 pCi/L. This value applies to the sum of all isotopes.
- k Secondary MCL.
- l Risk-based concentration calculated using cancer slope factors for Neptunium+D.
- m Risk-based concentration calculated using cancer slope factors for Radium-226+D.
- n Risk-based concentration calculated using cancer slope factors for Radon-222+D.
- o The EPA has deleted from the CFR both the MCL and the MCLG for nickel which have been vacated by court ruling, effective February 23, 1995 (60 FR 33926, June 29, 1995).
- p The MCLs listed here for Radium-226 and Total Radium actually apply to combined Radium-226 and Radium-228.
- q Federal and state MCLs were taken from the "Federal and State Guidelines" page found at the "Risk Assessment Information System" site at http://risk.lsd.ornl.gov/cgi-bin/guide/GUID_9709.